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Effect of Irrigation Levels and Crop Geometry on Growth, Yield Parameters and Yield of Fennel (*Foeniculum vulgare Mill.*) Cultivar Grown under Drip System

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ABSTRACT: A field experiment was conducted at the educational Farm, College of Agriculture, Swami Keshwanand Rajasthan Agricultural University, Bikaner in *rabi* season 2019-20 to study the effect of irrigation levels and crop geometry on growth and productivity on the cultivation of fennel (*Foeniculum vulgare Mill.*) cultivars grown under drip system. The results showed that irrigation at 1.0 PE gave maximum number of plant population (68762), plant height (118 cm), number of branches (primary branches 4.39, secondary branches 6.04), dry matter at harvest (30.30), number of umbels per plant (28.85), number of seeds per umbel (213.4) seed yield (17.32 qt ha^{-1}) and harvest index (34.21%) but all these parameters were at par with 0.80 PE irrigation level. Further, paired row sowing of 30 cm × 70 cm recorded significantly higher growth, yield attributes, seed yield and harvest index of fennel. It is therefore felt that for ensuring higher productivity of *rabi* fennel, suitable irrigation levels involving drip irrigation in conjunction with appropriate crop geometry need to be developed for arid and semi-arid conditions of Rajasthan.

Keywords: Crop geometry, drip irrigation, growth, productivity.

INTRODUCTION

Fennel (*Foeniculum vulgare* Mill.) an important seed spice in India is mainly grown during in Rabi season. Known as "saunf". It belongs to family Apiaceae or Umbelliferae. Fennel is a native of Southern Europe and Asia Minor. It is a biennial herb but it is grown as a pleasantly aromatic annual herb with feathery leaves and golden yellow flowers and every part (leaves, stalks, bulbs and seeds) is edible. The aroma is due to the presence of volatile oils *viz*., Anetholeand Fenchone. The seeds contain approximately about 9.5% protein, 10.0% fat, 42.3% carbohydrates, 18.5% fibre and 13.4% minerals and about 0.7% to 6.0% volatile oil depending on genotypes or plant types (Bhunia *et al.,* 2005). The volatile oils of fennel is used to control flatulent dyspepsia and colic in children (Mahfouz and Sharaf-Eldin 2007).

Fennel is grown mostly in Russia, Rumania, Hungary, Germany, France, Italy, India, Japan, Argentina, and USA. In India, it is mainly grown in the states of Gujarat and Rajasthan and some areas in Uttar Pradesh, Karnataka A.P., Punjab and M.P. as a rabi crop. Rajasthan and Gujarat are known as the "seed spices bowl" of the country. India is the largest producer of fennel with an area of about 79.84 thousand hectares with annual production of 128.50 thousand tonnes having a productivity of 1609 kg/ha. In Rajasthan, it occupies an area of 31.62 thousand hectares and production is 34.28 thousand tonnes with an average productivity of 1084 kg/ha (Spices board India, 2021-22).

In spite of this fact, the productivity of drilled rabi fennel in Rajasthan is just half of its potential productivity 2500 kg ha^{-1} (Patel *et al.*, 2000). The reasons for low productivity may be attributed to poor management practices particularly irrigation management. More than 75% of fennel growing area of Rajasthan has limited water resources. However, area and production both can be increased if the modern irrigation techniques like drip irrigation will involve in irrigating fennel in arid and semi-arid part of Rajasthan.

Poor irrigation planning often leads to low crop yields. In such areas having plenty and cheap water resources with secured supplies during the crop season, make it possible to apply water as and when required to assemble the full water required of crops and realize highest yields. On the other hand, in recent years water resources have become scare due to increase in cultivated area and poor renew of ground water especially in arid and semi-arid areas of Rajasthan. The limited availability of irrigation water has forced the idea of its efficient use by adopting the latest irrigation techniques like drip irrigation. Drip irrigation helps provide adequate soil moisture in the root zone, which increases yields and water use efficiency.

Efficient use of water resources is essential to sustain agricultural production, especially as land and water availability per capita declines. Drip irrigation systems also help reduce overuse of groundwater and environmental issues associated with surface irrigation methods, such as water absorption and salinity. The drip irrigation system optimizes the irrigation water and distributes the water evenly and directly to the root zone at repeated intervals according to the water needs of the crop through a network of closed plastic pipes. Many researchers have reported improvement in yield, quality and achieving higher water use efficiency as well as saving of water by using drip irrigation (Gao Yang *et al.,* 2010). Optimum plant geometry being non-monetary inputs exhibit dominant in increasing yield of fennel crop. Thus, proper crop geometry significantly increased seed and stover yield of fennel (Tamboli *et al.,* 2020).

Meager research has been conducted on the use of drip irrigation and crop geometry with regard to the production of Rabi fennel in arid and semi-arid regions of Rajasthan. It is therefore felt that for ensuring higher productivity of rabi fennel, suitable irrigation levels involving drip irrigation in conjunction with appropriate crop geometry need to be developed for arid and semi-arid conditions of Rajasthan.

MATERIALS AND METHODS

Field trails were conducted at Instructional Farm, College of Agriculture, S.K. Rajasthan Agricultural University, Bikaner (Rajasthan) during rabi season of 2019-20. Bikaner is located at 28.010N latitude and 73.220 E longitude at an altitude of 234.70 meters above mean sea level. The soil texture of the experimental field is sandy-loamy, showing a weak alkaline reaction (pH 8.5) and a low organic carbon content (0.12%), low available nitrogen (117 kg ha^{-1}), but average available phosphorus (15.4 kg ha^{-1}). The experiment adopted a split-plot design, repeated 3 times. The treatments consisted of four levels of irrigation *viz.,* 0.40, 0.60, 0.80 and 1.0 PE in the main plot, three crop geometry *viz.,* normal sowing at 50 cm × 20 cm row spacing, wide row sowing at 100 cm × 10 cm and paired row sowing at 30 cm × 70 cm in the sub-plot. Sowing was done by dibbling method using seed rate 10 kg ha^{-1} at the depth of 2-3 cm. Recommended dose of N and P_2O_5 i.e. 90:40 Kg per ha was applied through urea and DAP, respectively. The entire amount of P and 30 kg N were applied as basal dressing prior to sowing. While remaining nitrogen was top dressed in two equal splits doses (45 DAS and at flowering). The scheduling of irrigation was done with 0.40, 0.60, 0.80 and 1.0 PE at alternate day irrigations were applied through drip. The irrigation water was calculated using pan evaporation data. Dripper discharge rate per hour and one dripper cover area per plot were calculated for applying irrigation water and then calculated amount of water (1mm) was applied in the field to operate drip system per hour. This calculated time was multiplied with evaporation data and changed according to PE levels *viz*., 0.40, 0.60, 0.80 and 1.0 PE Other package of practices was followed as per recommendations made for the crop in region.

The seed yield of respective plot was added to stover yield to record biological yield per plot and finally accessible as qt ha^{-1}. One thousand seeds were counted from the sample drawn from finally winnowed and cleaned produce of each net plot and weight in grams was recorded separately for each net plot by electronic balance.

RESULT AND DISCUSSION

Effect of Irrigation levels on growth, yield attributes and yield. Data (Table 1 and 2) revealed that increasing irrigation levels from 0.40 to 1.0 PE increased growth parameters *viz.,* plant population, plant height, number of branches per plant, dry matter accumulation at harvest, yield parameter *viz.,* number of umbels per plant, number of seeds per umbel, yield and harvest index. However, plant population and plant height at harvest was not influenced due to different irrigation levels. Irrigation at 1.0 PE recorded significantly maximum dry matter accumulation at harvest (45.23g $plant^{-1}$), number of primary (6.49) and secondary branches $plant^{-1}$ (8.48) at harvest, maximum number of umbels per plant (28.85), number of seeds per umbel (213.4), seed (17.32 qt ha^{-1}), stover (35.84qt ha^{-1}), biological yield (52.25qt ha^{-1}) and harvest index (34.21%). However, number of branches, number of umbels per plant, number of seeds per umbel, seed yield at 1.0 PE at par with 0.80 PE irrigation level. Further, stover, biological yield and harvest index at 1.0 PE at par with irrigation levels of 0.80 and 0.60 PE. Data further showed that irrigation with 1.0 PE enhanced seed yield by 34.49 and 11.74 per cent over 0.40 PE and 0.60 PE irrigation levels, respectively. Higher irrigation levels (0.80 and 1.0 PE) helped in maintaining the stress-free conditions through absorbing much moisture and nutrients from soil which reflected in increased in cell turgidity and cell elongation which resulted better growth and development of plant and thus increased growth parameters, yield attributes and seed yield of fennel. The results of the present study are closely related to the findings of Bhunia *et al*. (2015); Giana *et al.* (2019).

Effect of crop geometry on growth, yield attributes and yield. Data (Table 1 and 2) indicated that growth, yield parameters and yield were recorded significantly maximum with crop geometry of paired row sowing at 30 cm × 70 cm. Data presented in Table 1 and 2 showed that highest plant population (72413), plant height at harvest (136 cm), number of primary (6.03) and secondary branches $plant^{-1}$ at harvest (7.96), dry matter accumulation at harvest (23.88 g $plant^{-1}$), number of umbels per plant (27.19), number of seeds per umbel (207.2), seed (15.98 qt ha^{-1}), stover (35.30 qt ha^{-1}), biological yield (52.57 qt ha^{-1}) and harvest index (32.56%) were recorded under paired row sowing of 30 cm × 70 cm. However, plant population and plant height at harvest was not influenced due to varying crop geometry. Further, results indicate that number of branches per plant, dry matter accumulation, number of umbels per plant, number of seeds per umbel were recorded significantly higher at paired row sowing of 30 cm × 70 cm compared to normal sowing at 50 cm × 20

cm row spacing and wide row sowing at 100 cm × 10 cm. The observed increase in seed yield due to paired row sowing at 30 cm × 70 cm was of the order of 2.17% and 5.27 % over normal sowing at 50 cm × 20 cm row spacing and 100 cm × 10 cm wide row spacing, respectively. The superior values under paired row sowing at 30 cm × 70 cm spacing, may be attributed to better growth and development of plants under plant population nearer to drip line which leads into better availability and utilization of water which further enhanced availability of balanced and adequate nutrients and moisture unlike in normal sown crop. These results are in conformity with findings of Mehta *et al.* (2012) in fenugreek and Bhardwaj and Agrawal (2014) in fennel.

Table 1: Effect of irrigation levels and crop geometry on growth parameters of fennel.

Treatments	Plant population at harvest (ha^{-1})	Plant height at harvest (cm)	Number of branches $plant^{-1}$		Dry matter accumulation at harvest (g $plant^{-1}$)
			Primary branches	Secondary branches	
Irrigation levels					
0.40 PE	68762	118	4.39	6.04	30.30
0.60 PE	71992	131	5.02	7.17	37.88
0.80 PE	73158	139	6.17	8.25	43.17
1.00 PE	74065	145	6.49	8.48	45.23
SEM ±	1094	3.5	0.14	0.15	0.52
CD at 5%	NS	NS	0.47	0.51	1.81
Crop geometry					
Normal sowing (50 cm × 20 cm)	71807	133	5.44	7.46	21.08
Wide sowing (100 cm × 10 cm)	71762	130	5.09	7.02	20.54
Paired sowing (30 cm × 70 cm)	72413	136	6.03	7.96	23.88
SEM ±	591	1.70	0.10	0.11	0.24
CD at 5%	NS	NS	0.29	0.34	0.73

Table 2: Effect of irrigation levels and crop geometry on yield attributes and yield of fennel.

Treatments	Number of umbels $plant^{-1}$	Number of seeds $umbel^{-1}$	Yield (qt ha^{-1})			Harvest Index (%)
			Seed	Stover	Biological	
0.40 PE	21.28	175.3	12.88	28.89	45.29	27.10
0.60 PE	25.78	198.0	15.50	33.57	50.01	32.01
0.80 PE	28.02	208.6	16.79	34.89	51.24	33.81
1.00 PE	28.85	213.4	17.32	35.84	52.25	34.21
SEM ±	0.63	1.95	0.21	1.01	1.04	0.86
CD at 5%	2.19	6.75	0.73	3.49	3.61	3.00
Crop geometry						
Normal sowing (50 cm × 20 cm)	25.70	197.7	15.64	33.05	48.86	31.51
Wide sowing (100cm × 10cm)	25.06	191.7	15.18	31.34	47.66	31.28
Paired sowing (30 cm × 70 cm)	27.19	207.2	15.98	35.30	52.57	32.56
SEM ±	0.38	3.13	0.17	0.64	0.836	0.56
CD at 5%	1.14	9.38	0.50	1.91	2.50	1.69

Interaction of irrigation levels and crop geometry on seed yield. Significantly higher seed yield (17.88 qt ha^{-1}) was recorded with irrigation level at 1.0 PE along with paired row sowing at 30 cm × 70 cm, which remained at par with 0.80 and 1.0 PE along with normal row sowing at 50 cm × 20. Data further 54 presented that at the same crop geometry, paired row sowing of 30 cm × 70 cm row spacing with 1.0 PE gave highest seed yield (1788 kg ha^{-1}), which was at par with 0.80 PE. It might be due to maintenance of water regime at nearer to field capacity in soil under drip irrigation system throughout the growing period and optimum plant to plant and row to row spacing which enhanced development with 0.80 and 1.0 PE levels. These results are in confirmation with the findings of Bhunia *et al.* (2015).

Table 3: Interaction of irrigation levels and crop geometry on seed yield (q ha^{-1}) of fennel.

Crop geometry	Irrigation levels			
	0.40 PE	0.60 PE	0.80 PE	1.00 PE
Normal sowing (50 cm × 20 cm)	12.33	15.33	17.13	17.83
Wide sowing (100 cm × 10 cm)	13.30	15.33	16.03	16.23
Paired sowing (30 cm × 70cm)	13.00	15.83	17.22	17.88
SEM ±	0.33			
*CD at 5%	0.99			
SEM ±	0.34			
**CD at 5%	1.09			

CONCLUSIONS

Results of the present investigation showed that the Irrigation level 1.0 PE with paired row sowing of 30 cm × 70 cm gave significantly highest growth parameters, number of umbels per plant, number of seeds per umbel, yield and harvest index were statistically at par with 0.80 PE.

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Conflict of Interest. None.

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